A concussion education programme for motorsport drivers

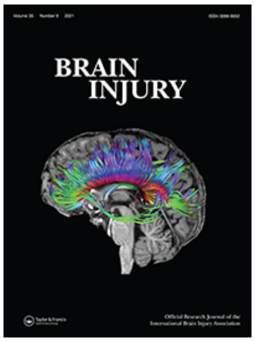
Citation for published version:
Adams, S, Richards, H, Sproule, J, Hutchinson, PJ & Turner, T 2021, 'A concussion education programme for motorsport drivers: A field-based exploratory pilot study', *Brain Injury*, vol. 35, no. 9, pp. 1011-1021.
https://doi.org/10.1080/02699052.2021.1944669

Digital Object Identifier (DOI):
10.1080/02699052.2021.1944669

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
Brain Injury



Brain Injury

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ibij20

A Concussion Education Programme for Motorsport Drivers: A Field-Based Exploratory Pilot Study

Stephanie A. Adams, Hugh Richards, John Sproule, Peter J. Hutchinson & Anthony P. Turner

BRAIN INJURY
2021, VOL. 35, NO. 9, 1011–1021
https://doi.org/10.1080/02699052.2021.1944669

A Concussion Education Programme for Motorsport Drivers: A Field-Based Exploratory Pilot Study

Stephanie A. Adams[a], Hugh Richards[a], John Sproule[a], Peter J. Hutchinson[b], and Anthony P. Turner[a]

[a]Institute for Sport, PE & Health Sciences Moray House School of Education, University of Edinburgh, Edinburgh, Scotland; [b]Academic Division of Neurosurgery, Addenbrooke's Hospital, University of Cambridge, Cambridge, UK

ABSTRACT

Objective: Concussion education strategies that improve knowledge and attitudes long term are needed. This exploratory study piloted an interactive concussion education program, adopting concepts from the learning sciences and attitude change literature, for the underserved and high-risk population of motorsports.

Method: Forty UK motorsport drivers (ages 16–20 years) participated. The workshop group received a two-phased workshop-based program. The comparison group received a concussion leaflet. Participants completed an adapted version of the Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS-ST) at pre-, post- and 2-month follow-up. Within-group analysis for the workshop group explored the differential effect of the individual difference variable, Need for Cognition (NfC), and effectiveness was explored through post-workshop questionnaires and interviews.

Results: Unlike the comparison group, the workshop group showed a significant improvement in knowledge over time ($F(2,58) = 45.49$, $p < .001$, $^{\eta 2}p = .61$). Qualitative data indicated workshop-program participants developed safer attitudes toward concussion following programming. Preliminary evidence suggested individuals' responses to concussion education aligned with differences in NfC.

Conclusion: This study piloted the first concussion education program for motorsport drivers and explored whether aligning educational provision with the NfC construct may help to improve program effectiveness. Findings are relevant to addressing the public health issue of concussion through educational approaches.

ARTICLE HISTORY
Received 12 August 2020
Revised 01 June 2021
Accepted 14 June 2021

KEYWORDS
Traumatic brain injury; need for cognition; health education; knowledge; attitudes

Introduction

Concussion, broadly defined as a traumatic brain injury induced by biomechanical forces (1), is a worldwide public health concern (2) that contributes to a global burden of disability, public health-care costs, and significant socioeconomic impact on families (3). Recent increases in concussion incidence in sport have been widely reported. While this may reflect increased awareness and reporting, the significant adverse effects of concussion (3) requires this issue to be further researched. Effective strategies to prevent, diagnose, and improve subsequent management of concussion in sport are the subject of debate, however education has emerged as a key strategy (1,4). In some world regions, concussion education programs are mandatory for athletes and coaches (5). However, evidence on the effectiveness of many education programs is limited as is determining the optimal delivery approach.

The majority of concussion education approaches have involved passive dissemination methods (e.g., leaflets, static websites, didactic lectures) or a single workshop, and have targeted athletes (e.g., ice hockey, football, rugby) in North America between the ages of 9–21, with a few programs targeting coaches and parents (6). Evaluations have indicated poor knowledge retention and no effect on attitudinal changes (6). The lack of effectiveness may be partly to do with *how* the messaging and content is taught and consequently cognitively processed by participants.

Content, delivery methods and communication strategies all impact on the effectiveness of concussion education (5). Contrary to popular belief, learning is not intuitive, and approaches to education that are beyond passive dissemination and are grounded in the learning sciences have potential to enhance program effectiveness (7). Positively, Caron, Rathwell, Delaney, Johnston, Ptito and Bloom (8) introduced multiple, spaced learning sessions to concussion education, which showed positive effect. Compared to massed approaches to learning, the evidence shows that spaced, and repeated, learning sessions are significantly better for retention and comprehension (9,10). While Caron et al. (8) found knowledge improved following their program, no significant improvement in attitude was identified. This must be addressed further, and a science-based approach to learning should provide the evidence for this investigation, including drawing from the evidence on individual differences in cognition. Targeting and improving both knowledge and attitudes is important because knowledge alone does not lead to behavior change (11); attitude influences behaviors and behavioral intentions (12).

CONTACT Stephanie A. Adams stephanie.adams@ed.ac.uk Institute for Sport, PE & Health Sciences Moray House School of Education, University of Edinburgh, Edinburgh, Scotland

Decades of health communication research has indicated that individual difference variables can influence how health messages are received, interpreted and retained (13,14). One such individual difference factor is Need for Cognition (NfC). NfC is a relatively stable individual difference variable in cognitive motivation that relates to the extent to which an individual engages in and enjoys effortful thinking (15,16). An individual's NfC influences ability and motivation to take on health information and partially determines the impact of delivery methods (e.g., videos, statistics) (17). Typically, individuals with greater NfC engage in more effortful thinking, are more influenced by substantive arguments and more likely to prefer complex tasks (18,19). Individuals with greater NfC are demotivated to process information that appears simple and unchallenging, while individuals with low NfC prefer simple tasks and respond more positively to images over text (18–21). Recent work on attitude change in sport (related to doping) has suggested that individual differences in NfC can affect the impact of programs (22). Recently in the area of concussion, Turner, Tollison, Hopkins, Poloskey and Fontaine (23) surveyed 353 athletes (mean age = 19.8 yrs) and found that it was not only participants' ability to understand health information that determined knowledge of concussion symptoms but also their motivation to think deeply about concussion (i.e. their NfC) (22).

Addressing individual differences in NfC within concussion education has potential to improve ability and motivation to process and engage with health messages. A more tailored approach may address prior limitations associated with program effectiveness related to "one size fits all" concussion programming. It is important to investigate how matching concussion education delivery and content with athlete's NfC preference (e.g. high or low) might enhance impact.

A population that could derive high benefit from a focus on NfC is motorsport (e.g., F1, rally, karting). The incidence of concussion in motorsport drivers is rising and high compared to other high-risk sports (24–27). Reported incidence varies from 6.3% to 35% (26). After adjusting for national sport participation rates, Finch, Clapperton and Mccrory (28) found concussion rates were highest for motorsports (181/100,000 participants), followed by equestrian activities and rugby (130/100,000 and 49/100,000 participants, respectively). Motorsport is a small, highly complex, and individualized sport that is under-researched in sport science and medicine (26,27). Further, despite the enormous G-forces exerted on the athletes (herein referred to as drivers), evident risks and highly publicized concern for driver safety (26,27), there is no published research on concussion education programs in motorsport. Unlike other sports where concussions are also common (e.g., rugby, football), motorsport drivers often travel to and from races independently without support (e.g., coach, family member), and the availability of on-site medical personnel/resources varies widely by region, race series, and level (24,27). Our survey research on concussion in UK motorsport evidences the need for concussion education in motorsport (24), with reported increases in incidence (26) but also a lack of knowledge and mixed attitudes in drivers (24).

The current exploratory research utilizes a rare opportunity to access a convenience sample of young competitive racing drivers, an ideal target population given the aforementioned motorsport context, and evidence suggesting adolescents and emerging adults may be most susceptible to concussion and persistent symptoms (1). This study involved developing and piloting an interactive concussion education program. We used a mixed-methods design to explore changes in knowledge and attitudes, and drivers' responses to the program relative to their NfC.

The research questions addressed in this paper are:

(1) Does a workshop-based concussion education program lead to improved knowledge about concussion in a group of young motorsport drivers?
(2) Does a workshop-based concussion education program promote safe attitudes toward concussion and is this evidenced in quantitative and qualitative responses?
(3) How do the drivers' responses align with individual differences in Need for Cognition (NfC) and is there a role for NfC in concussion education programs?

Methods

Design

The main aim of this exploratory pilot study was to explore the impact of the workshop program. To achieve this, quantitative pre-, post- and follow-up data were collected from workshop participants. Post-program interview data were also collected from a sample of workshop participants. This qualitative data provided additional explanatory information about the workshop program to address the research questions (29). For comparison, and to rule out other potential causes of change to concussion knowledge and attitudes, an inactive comparison group (30) was included and this group received a gold-standard concussion leaflet. Only quantitative pre- and post-leaflet data were collected from the comparison group and further rationale for this is described below. Ethical approval for the study protocol was provided by the institutional ethics committee at the University of Edinburgh.

Participants

All participants were enrolled by Motorsport UK, the national governing body, using convenience sampling. We were provided access to a full cohort of 30 UK motorsport-licensed drivers (Mage = 17.4 years; 78% men) to take part in the *workshop-based program*. Ten UK motorsport-licensed drivers (Mage = 17.1 years; 70.0% men) took part in a separate *comparison condition* that were instead provided with a concussion leaflet. These participants were also recruited by Motorsport UK through targeted e-mail invitation. Inclusion criteria for this study were as follows: 16–20 years of age; active motorsport competitor (last 12 months); current Motorsport UK race license holder. All participants provided informed written consent. Participant characteristics, obtained via questionnaire, are summarized in Table 1.

Measures & materials

Concussion knowledge & attitudes

The 55-item Rosenbaum Concussion Knowledge and Attitudes Survey – Student Version (RoCKAS-ST; 31)

Table 1. Participant demographic information by group.

	Workshop group (N = 30)	Comparison group (N = 10)
Age (years) (M, Range)	17.4 (16–20)	17.1 (16–18)
Sex (N) (%)		
Male	22 (73.3)	7 (70.0)
Female	6 (20.0)	3 (30.0)
Unknown	2 (6.7)	0 (0.0)
NfC (M)(Median)	53.9 (54.0)	56.5 (55.5)
Subtype (N)(%)		
Circuit	14 (46.7)	2 (20.0)
Rallying	4 (13.3)	5 (50.0)
Karting	8 (26.7)	3 (30.0)
Rallycross	1 (3.3)	0 (0.0)
Unknown	3 (10.0)	0 (0.0)
Level (N)(%)		
Amateur	16 (53.3)	9 (90.0)
Professional	8 (26.7)	1 (10.0)
Both	3 (10.0)	0 (0.0)
Unknown	3 (10.0)	0 (0.0)
Concussion history (N) (%)		
Yes	2 (6.7)	3 (30.0)
No	20 (66.7)	6 (60.0)
Not sure	5 (16.7)	1 (10.0)
Unknown	3 (10.0)	0 (0.0)

NfC = Need for Cognition. Concussion history = History of concussion in motorsport. Unknown = missing data.

provides two index scores; concussion knowledge (CKI), and concussion attitude (CAI). The RoCKAS-ST reportedly demonstrates satisfactory test–retest reliability (CKI items: r = .67; CAI items: r = .79) and internal consistency (Cronbach's α = .59-.72) (31). The CKI-subscale in this study showed good internal consistency (Cronbach's α = .82) and the CAI-subscale showed acceptable internal consistency (Cronbach's α = .71). The RoCKAS-ST has been described extensively in the literature, and further details on the measure can be found in Caron et al. (8). Terminology was adapted to suit the motorsport context (e.g. 'athletes' to 'drivers'; 'return to a game' to 'return to an event') (24).

Knowledge and attitudes were also assessed qualitatively through semi-structured interviews. An interview schedule, comprising 6 main questions with additional prompts and probes (32), was adapted with permission (8). Questions were reviewed and agreed by the research team and a Motorsport UK official.

Need for cognition

Assessed using the 18-item, short form Need for Cognition scale (NfC) (33). Participants rated items (e.g., "Thinking is not my idea of fun") on a 5-point scale (1 = extremely uncharacteristic of me, to, 5 = extremely characteristic of me). Higher scores (range 18–90) indicated higher NfC. The scale has demonstrated good test-re-test reliability (α = .88) (15) and showed 'acceptable' internal consistency (Cronbach's α = .76) in the present study. It is not influenced by gender, social desirability, differences in test-taking anxiety or cognitive style (15) and has been used in a variety of related settings, (e.g. student attitudes toward exercise) (34).

Workshop questionnaires

A short post-workshop questionnaire was developed which assessed participants' responses to elements of the workshops in accordance with high NfC (e.g., preference for graphs/data and engaging in discussions/tasks) or low NfC (e.g., preference for brief videos and limited thinking) (18–21,33). Participants responded to questions using forced-choice responding, to reduce response biases such as acquiescence responding (35).

Forced-choice in this study required participants to distribute 5 points between pairs of statements (e.g., "The video clip with Dr Stephen Olvey sufficiently helped me in learning about the signs and symptoms of concussion" versus "The signs/symptoms sorting task activity and follow-up discussions were most beneficial to me in learning about the signs and symptoms of concussion"). The greater number of the points given to a statement indicated participants' agreement/preference. A copy of the questionnaires can be obtained from the first author.

Workshop-programme structure and content

The workshop program consisted of two interactive sessions. The sessions were spaced 4 weeks apart. Each workshop lasted 90 minutes and was delivered by a facilitator who was both a trained educator and concussion researcher. Facilitation methods were informed by the learning and psychological sciences of cognition (9,10). Delivery techniques included videos, active demonstrations, group activities and competition (e.g. card sorting; working in a team to create sport-specific physical and psychological RTP protocols), revision/discussion, case studies and practicing relevant hypothetical scenarios.

The program in this study was designed to provide a motorsport-tailored and age-appropriate concussion education experience while working to improve knowledge and attitudes toward the topic. Motorsport-specific contextualization, examples, and case studies were created through discussions with expert stakeholders. While being tailored to motorsport, the fundamental concepts within the area of concussion were covered (1,8). Workshop 1 covered: the definition of concussion; mechanisms of injury; signs and symptoms of concussion; basic pathophysiology; the physical, psychological and emotional impact of concussions and the potential short- and long-term effects on health and well-being as well as sport performance. Workshop 2 covered: a review of workshop 1 and further discussion of the potential effects of concussion on performance and daily living; return to normal/learn and return to sport processes and protocols; consideration of safe sporting environments and looking out for others. All evidence taught in the program was based on the latest peer-reviewed literature (e.g., 1,6,8,36).

Comparison programme information

The Scottish Sports Concussion Guidance leaflet (37) was disseminated. This leaflet is a pioneering, nationally endorsed cross-sport document covering a range of concussion topics including causes, symptoms, management and RTP.[1]

Procedure

Measures and workshops were reviewed by relevant professionals with expertise in psychology, adolescent development, education, and secondary school teaching and were piloted before use.

Procedural time points were adapted from the literature (6,8) to meet the availability of the Motorsport UK stakeholders. Following informed consent all groups completed the baseline (pre-test) questionnaires (RoCKAS-ST, NfC) 1-week before receiving either the first workshop or the leaflet. During week 2, the comparison group received the educational leaflet for reading and the workshop group received the first workshop. The workshop group received the second workshop four weeks later and completed the RoCKAS-ST at the end of this session (post-test). Both groups repeated the RoCKAST-ST 2-months later (follow-up).

Further, the workshop group completed the evaluation Workshop Questionnaire after each session. Approximately 3 months after the second workshop, 13 (43%) workshop group participants completed individual follow-up interviews via Skype or telephone. Interviews lasted approximately 15–20 minutes and were audio recorded and then transcribed. Interviewees were purposively sampled to represent different motorsport subtypes and sampling stopped when data saturation (38) was achieved.

Data analysis

Quantitative

Statistical analyses were conducted using IBM SPSS 22.0 (SPSS, Armonk, NY). Significance level was set to $p< .05$. Demographic data was summarized using means, medians, frequencies and percentages. CKI and CAI scores were computed (31) for both groups. The Shapiro–Wilk test of normality indicated some violation for the workshop group (pretest CAI, $p = .03$; and follow-up CKI, $p = .008$); however, Q–Q plots and studentized residuals showed this was minimal. We therefore proceeded with ANOVA analyses, which are robust to violations of normality (39,40). Sphericity was assumed for CKI and CAI workshop group data, (Mauchly's test of sphericity (X2 (2) = 2.14, $p = .342$, and X2(2) = 1.31, $p = .520$, respectively).

Workshop group

Knowledge (CKI) and attitudes (CAI) were evaluated using one-way repeated measure ANOVAs across pre-program, post-program and follow-up time points (39). Workshop group participants were then divided into 'low NfC' (M = 43.33, SD = 7.05) versus 'high NfC' (M = 63.50, SD = 4.18) groups according to baseline NfC scores and their 'workshop questionnaire' data was described descriptively according to this group membership ('low NfC,' 'high NfC'). This provided exploratory insight into how individual differences in Need for Cognition may be reflected within concussion education, and how participants may have preferences for how they receive information and differences in the depth at which they engage with the learning process (15,17; e.g., High NfC showing preference for graphs/data and engaging in discussions/tasks, or low NfC showing preference for brief videos and limited thinking time (33)).

Comparison group

Knowledge (CKI) and attitudes (CAI) were each evaluated using within-subject t-tests (pre- to post-leaflet).

Qualitative

Interview transcripts were analyzed thematically (41) using Quirkos Software (Version 1.5.0, Quirkos Limited, Edinburgh). Transcripts were read multiple times and initial codes were assigned to relevant meaning units, which were then extracted and organized deductively into the higher-order themes of, 'Concussion Knowledge' and 'Concussion Attitudes.' Lower-order themes were identified inductively. To establish trustworthiness (42), two other trained researchers independently reviewed codes and themes. Initial inter-rater agreement scores were 86% and 80%, respectively. Following discussions between the researchers, minor changes were recommended to some theme names to increase clarity for the reader and to better reflect the data, and all discrepancies were resolved.

Results

RoCKAS-ST

Workshop group

There was a significant change in CKI over time ($F(2,58) = 45.49$, $p < .001$, $^{\eta 2}p = .61$ (large effect)), with CKI scores increasing from pre-program (M = 24.00, SE = .53) to post-program (M = 28.11, SE = .46) then decreasing at follow-up (M = 26.80, SE = .38). Post-hoc analysis with a Bonferroni adjustment showed CKI significantly increased from pre-program to post-program (Δ = 4.11, $p< .001$), and from pre-program to follow-up (Δ = 2.80, $p< .001$). There was a statistically significant decrease in CKI from post-program to follow-up (Δ = −1.31, $p= .013$). These results suggest that concussion knowledge improved overall as a result of the workshop program. There was, however, no significant difference in CAI over time ($F(2,58) = 1.64$, $p = .204$, $\eta 2p = .05$ (small)). Mean scores were 55.55 (SE = .92 pre-test), 57.11 (SE = .56) at post-test, and 56.98 (SE = .89) at follow-up (see Figure 1 and 2).

Comparison group

There was no significant difference between CKI scores at baseline (M = 27.90, SE = .81) and follow-up (M = 27.10, SE = .31), $t(9) = 1.206$, $p = .259$, $d= .41$ (Figure 1). There was also no significant difference between the group's CAI scores at baseline (M = 56.00, SE = 2.30) and follow-up (M = 55.00, SE = 2.23), $t(9) = .852$, $p = .416$, $d = .14$ (see Figure 2).

Interviews

Participants described different areas of "Concussion Knowledge" they reported learning about as a result of

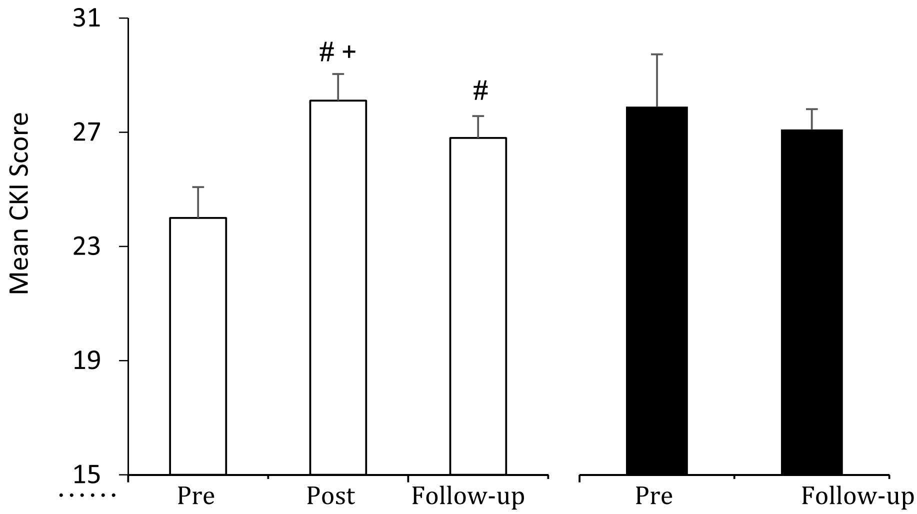


Figure 1. Mean group scores for concussion knowledge (CKI) for the Workshop (white bars) and Comparison (black bars) groups at pre-intervention (Pre), post-intervention (Post) and 2-month follow-up. Error bars represent 95% confidence intervals. #Significantly greater than Pre, $p < .001$; +significantly greater than follow-up, $p < .001$.

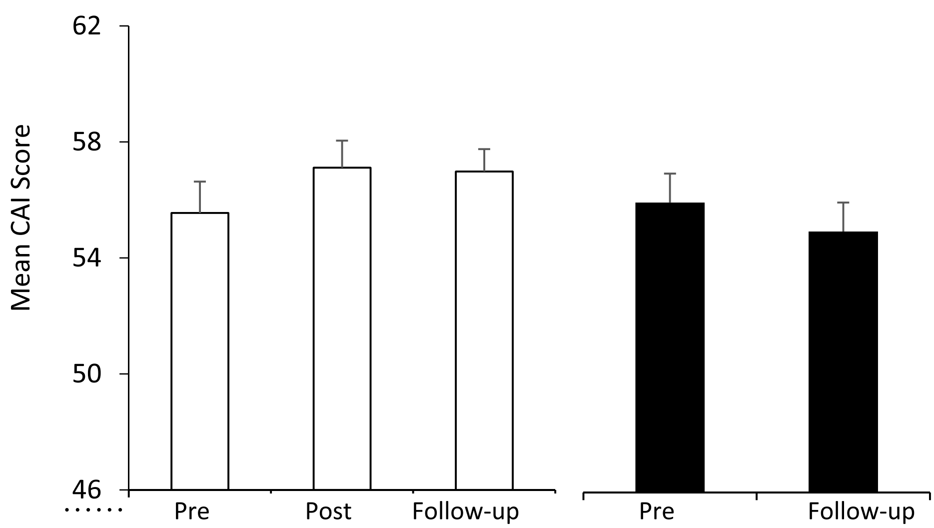


Figure 2. Mean group scores for concussion attitudes (CAI) for the Workshop (white bars) and Comparison (black bars) groups at pre-intervention (Pre), post-intervention (Post) and 2-month follow-up. Error bars represent 95% confidence intervals.

the programming. This included four sub-theme categories: *Sign and symptom awareness* (77% of total sample), *Managing concussion* (62%), *Susceptibility and severity* (62%), and *Mechanisms of concussion* (23%). Table 2 indicates the development of participants' knowledge about the range of symptoms and how they can "differ compared to what most people think they are." Participants reported greater awareness of cognitive and/or emotional symptoms in addition to physical. Participants explained learning that "small impacts can lead to concussion," and that it does not need to be a direct hit to the head. They also recounted the importance of the staged return processes and making short-term adjustments to training/competition as well as activities including TV, mobile phone use, and driving. The potential impact on people's lives and athletic performance was also discussed.

The second main theme represented changes to participants' beliefs and attitudes toward concussion since taking the program. This theme, "Concussion Attitudes" contained four sub-themes including *Perceived seriousness* (69% of total sample), *Intention to report* (62%), *Personal responsibility* (38%), and *A physical & mental injury* (23%). As a result of the workshops, participants reported thinking more about their personal role or responsibility in responding to concussion, and that competing while concussed puts others in danger as well as themselves. They also discussed that they would now be more likely to report symptoms and seek medical attention following

Table 2. Influence of education programming on knowledge and attitudes toward concussion.

Main theme	Sub-Theme	Supporting quotes
Concussion Knowledge	*Signs and symptom awareness (N = 10)*	"I learned all the different symptoms of concussion that I didn't really think [about before] . . . " [Participant 2] "not all the signs of a concussion are really obvious . . . you have to think about like what you're coping with." [Participant 5] "I wasn't aware of how much it can affect you emotionally" [Participant 13]
	Managing concussion (N = 8)	" . . . see a doctor right away at least . . . things like avoiding driving, using a mobile phone, anything like that over stimulates . . . ." [Participant 2] "you need to be taking a break if you do get a concussion rather than continue with your competition" [Participant 22] "don't drive anywhere, and use much heavy machinery or cars or anything else just because in case they do have side effects happen when they are using that, then it could have a serious impact on them." [Participant 23] "I know it's important to slowly get back into everything, like go for a steady walk, and there's steps that you have to go through. . . . you have to take the steps to be safe . . . going slowly upwards so they can get back them same self." [Participant 13]
	Susceptibility and severity (N = 8)	"I learned that if you have one concussion you're more likely to get another" [Participant 5] "[I didn't know before] how much it can reduce your performance." [Participant 19]
	Mechanisms of concussion (N = 3)	"I learned that you don't have to be knocked out to be concussed . . . " [Participant 20] "I learned like it doesn't actually need to be that big of an impact to be concussion." [Participant 19] "you think, 'oh, it has to be a hit to the head,' but it doesn't'." [Participant 13]
Concussion Attitudes	*Perceived seriousness (N = 6)*	"it's a lot more serious than what I first thought" [Participant 5] "it is a bigger concern to me now that I know more about it." [Participant 20] "I think it's something that needs to be brought to attention more. A lot of people don't really understand how much it could actually affect someone, it's changed my view in regards to the safety, and how much more important everything is now . . . " [Participant 6]
	Intention to report (N = 8)	"it would now change what I would do if it happens. I would now definitely go to the doctors and take all their advice . . . ." [Participant 5]
	Personal responsibility (N = 5)	"now that I know a lot more about them I would have probably not drove on and would have sacrificed that round, for the safety of everybody else and myself as well. It definitely is something that I'm consciously thinking about now . . . you could be putting yourself in danger doing the next race or, in fact, putting other people with you on the track in danger and at risk as well." [Participant 23] "until you know you've got the clearance from your doctor and you feel not only, from what your doctor said, but you feel in yourself that you're good, I think that's quite important" [Participant 6]
	A physical & mental injury (N = 3)	"now [I think of concussion as] a physical and mental injury" [Participant 2]

an accident. Following the program participants reported believing that concussion was more serious than they previously thought (e.g., more than just a physical injury) and that "a lot more people need to be aware of it" (Table 2).

NFC

Figure 3 shows participants in the 'lower NfC' group showed a preference for the statements considered to be characteristic of those with lower NfC. Likewise, participants with 'higher NfC' preferred the statements considered characteristic of higher NfC. For example, participants with 'lower NfC' gave the sign and symptom video clip a higher rating, while those with 'higher NfC' gave the sign and symptom-sorting task and discussion a higher rating. Those with 'lower NfC' rated brief videos higher than those with greater NfC, while those with 'higher NfC' rated 'liking evidence and data' higher than those with 'lower NfC.'

Discussion

This is the first evidence that a workshop-based concussion education program for motorsport drivers can significantly improve concussion knowledge (large effect sizes). While knowledge scores at 2-month follow-up declined, these remained significantly greater than the pre-program level. Participants who were instead provided with a concussion leaflet did not show any improvements from pre- to follow-up. Evidence from this exploratory study supports the effectiveness of the workshop-program to significantly improve knowledge about concussion. No statistically significant changes in attitudes toward concussion were detected by the ROCKAS-ST. In contrast, the qualitative data from the workshop group showed evidence of safer attitudes following the program. This study emphasizes the value of mixed-methods approaches to assess concussion attitudes, and suggests potential benefit of aligning individual Need for Cognition with educational provision.

Concussion knowledge

This evidence, demonstrating improvements in concussion knowledge following the workshop programme extends findings from cross-sectional motorsport survey data (24,43). The decrease in knowledge scores between post-test and follow-up is consistent with previous studies (8,44); however, importantly, follow-up levels remained statistically better than baseline, with large effect sizes. The RoCKAS-ST has been used previously to assess the effects of concussion education programs with student-athletes in North America (8,45). UK motorsport drivers in the current study reported on average lower CKI scores compared to Caron et al. (8) but showed a greater (%) increase in scores from pre- to 2-month follow-up. The relatively lower CKI scores in the current sample may reflect greater exposure to concussion education (including legislative changes) in North American sport and

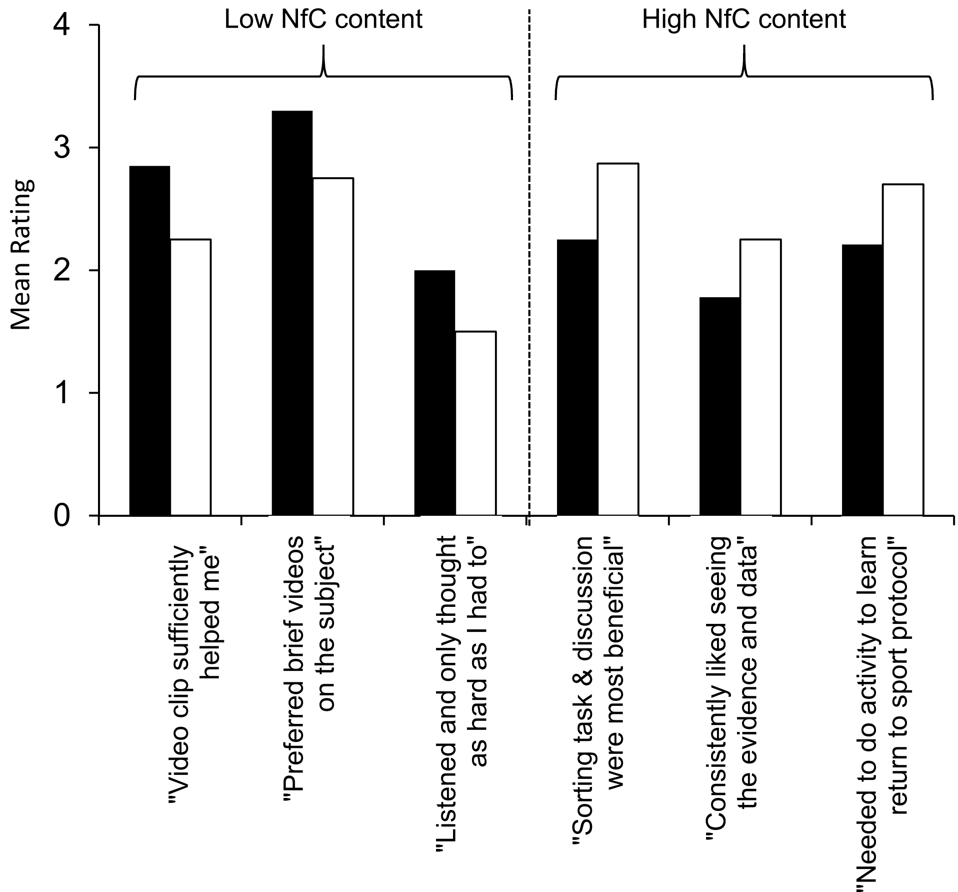


Figure 3. Mean self-reported ratings for exploratory NfC scenarios in participants with lower (solid black bars) or higher (open bars) Need for Cognition (NfC), separated by low versus high NFC content.

further supports the need for more education within the UK setting.

The RoCKAS-ST does not assess knowledge for all key concepts typically taught during concussion education programs. For example, understanding of return to learn (RTL) and play (RTP) protocols (key concepts of the current consensus guidelines (1) is not assessed by the measure but can be investigated in depth through interview or focus group methods. In this study, qualitative data from drivers in the workshop-program demonstrated an understanding of concussion management procedures and how to effectively adapt and implement the staged RTL/RTP protocols for the motorsport context. Qualitative data also showed drivers demonstrated greater depth to their knowledge about concussion signs and symptoms as well as commonly overlooked complexities (e.g., symptoms being individualized and comprising emotional and cognitive features as well as physical). Furthermore, as a result of the workshop program drivers understood the mechanisms and severity of the concussion injury, including its impact on daily living. Qualitative data in this study was able to assess a wider range of changes and further demonstrates the value of this methodology (8).

Concussion attitudes

Attitude toward concussion, assessed through the RoCKAS-ST, did not show significant change following the workshop program, or leaflet. This finding is consistent with previous literature which suggests the subscale has a ceiling effect, reducing its ability to detect change (8). However, in contrast to the scale ratings, the qualitative data from workshop participants indicates important attitude changes. Following the program, workshop participants expressed intention to behave differently in the event of a concussion (“*change what I would do … .go to the doctor”)* and to relinquish primary performance goals *(“would have sacrificed that round, for the safety of everybody else and myself*”); both underpinned by changed attitude *(“it’s changed my view … . how much more important”)* and demonstrating the drivers’ higher order thinking associated with taking action to avoid potential negative impacts of their own concussion on others; an important decision in high-speed motorsports.

This evidence provides support for the effectiveness of the program to create meaningful and important attitude change that is relevant to the motorsport environment and raises questions about the sensitivity of the RoCKAS-ST attitude scale alone to detect meaningful changes.

Williams, Langdon, McMillan and Buckley (46) found inconsistency between RoCKAS-ST responses and interview data and discussed potential social desirability bias with the measure. While evidence of such bias was not found in the current study the repeated inconsistency between rating scale and interview data suggests weaknesses in the RoCKAS-ST to investigate attitude changes.

Need for cognition

Recognizing the need to account for differences in learners' ability and motivation to cognitively process health-related messages (12), we explored the potential role NfC might have in enhancing the impact of concussion education with the workshop group. Findings were consistent with theory underpinning NfC (18–23). Learners engaged more strongly with elements of the workshop programming that corresponded with their underlying NfC (high NfC preferred detail and explanation; low NfC preferred image/video over text/depth; see Figure 3). To understand this relationship further we reviewed text extracts from interviews and found patterns consistent with the principles of NfC. For example, interviewees with higher NfC spoke more about "thinking" and articulated increased awareness and a sense of responsibility in comparison to those with lower NfC. While only exploratory, these preliminary findings support the potential role of NfC within concussion programming to improve effectiveness on key outcomes.

Tailoring health education programs to NfC has been investigated previously in areas including AIDS (47), cancer prevention (48,49) smoking cessation (50), and exercise behavior (34). Cortese and Lustria (51) found that a website education program for participants (n = 151; ages 13–17 years old) produced deeper processing of information when it was tailored to NfC than a non-tailored equivalent, and Williams-Piehota et al. (49) argued the need to tailor programming to suit those with both low and high NfC to enhance program effectiveness. In short, cultivating opportunities for deeper processing, and taking cognitive effort into consideration, during the design and delivery of concussion education is needed. Tailoring for NfC within programs may improve, and expedite, how participants engage with and consider concussion information, and positively impacting knowledge and attitudes, provided the delivery and content are sufficiently stimulating for participants to invest cognitive effort (52). This evidence, together with the data from the current study, supports further investigation into the potential role of tailoring concussion education according to NfC. We believe that alternative recommendations to consider tailoring to 'learning styles' (1), however, should be disregarded given the significant weight of recent evidence against the validity of such constructs (53–56).

Limitations and implications for future research

Recruiting drivers as participants, while maximizing ecological validity, introduced restrictions on availability and access through Motorsport UK. With exploratory research small sample size is common and there is no straightforward answer to the question of how many, i.e. participant accessibility influences the richness of any generated data and sample sizes are considered large enough if they reveal novel data. However, this should be addressed through ongoing evaluation as programs scale. Requests from research partners to minimize participant burden meant only pre- and follow-up questionnaire data were collected from the comparison group. As mentioned previously, motorsport is a small and individualized sport that is under researched, particularly in the area of concussion (26,27). Thus, we used the opportunity we were provided to access the (smaller) comparison group of drivers that were given and asked to read a 'gold-standard' concussion leaflet; real-world practice which is often not evaluated. Despite these design limitations, we saw value in looking at current standard practice in addition to the workshop program. We acknowledge that this study does not enable a direct like with like comparison. That is, the design does not include a traditional matched control group alongside an intervention, but instead uses an inactive comparison group, a type of control group which, practically, can help highlight whether participants benefit from receiving the treatment package (in this case the workshop program) compared to not receiving it and when this control-group design is appropriately communicated helps to prevent biased conclusions regarding the effect of the main intervention (30). We believe this design is superior to using a group with no treatment (44,57), or materials unrelated to concussion (58), although acknowledge present weaknesses.

Future research should build on this exploratory work, including a more equally matched comparison group (in sample size and time points) to elucidate if common methods of disseminating concussion information (i.e., printed materials on their own) are ineffective against other forms of intervention programming. Further, as part of future evaluations, the new purpose-made Workshop Questionnaires should be validated. It is currently unknown whether the present findings generalize beyond the context of adolescent drivers in the UK. Further research is needed in this area. Despite these limitations, the current pilot provides leading groundwork with practical application within motorsport.

Longer follow-up periods are needed in order to evaluate sustained impact of programs on both knowledge and attitudes as well as behaviors in practice (6,8). As mentioned earlier, knowledge alone does not lead to behavior change (11) but attitudes play a critical role in influencing both behavioral intention and subsequent behaviors (12). Therefore, attitude and cultural change should be a key focus of concussion education programming. Matching health messages to individual difference variables, such as NfC, increases the effectiveness of changing attitudes and behaviors (59,60). Thus, in addition to including longer follow-up periods, further research is needed to clarify the present exploratory findings regarding NfC, to determine the construct's relevance to improving attitudes and program effectiveness within the context of concussion.

At the time of the present research there was no alternative, standardized knowledge and attitude measure to the RoCKAS-ST. Present findings, however, provide further evidence (61) to suggest the need for more robust measures of concussion-related attitude change in particular. The CAI items within the RoCKAS-ST may be limited and outdated. Qualitative data in the present study may indeed be a better representation of concussion attitudes. Researchers are encouraged to develop new measures, using more nuanced measures, such as implicit measures of attitude assessment (62).

Maintaining the use of multiple-spaced learning sessions is recommended in future concussion education programs in order to prevent participants from feeling overwhelmed by content (8). Cognitively, this practice also allows time for revision, building on previous material, ability to seek clarification of concepts, and leads to better learning. The importance of spacing learning sessions instead of using a single massed session is well evidenced to reduce memory decay (9,10).

One educational strategy that can help to support spaced learning is the Massive Online Open Course (MOOC). This has been recently introduced to concussion, led by researchers in Canada (63). Importantly, a MOOC can support spaced learning and thus may help to support better learning retention and deeper processing of the content (64). Online educational technologies like a MOOC may also offer the ability to more rapidly update educational content as further consensus evidence is published, as well as the means to tailor to individual difference variables such as NfC. Moreover, as part of increasing learners' ability and motivation to process content, maintaining the use of content and materials that are sport-specific is recommended (5).

Conclusion

This exploratory study piloted the first concussion education program for motorsport drivers. It is also the first concussion education program to explore the potential role of Need for Cognition (NfC) in improving education effectiveness. Findings suggest the current workshop-based concussion education program can improve concussion awareness in motorsport drivers. There may be benefit of aligning individual NfC with concussion educational provision and future research should explore this further.

Note

1. This was updated in 2018 (65).

Acknowledgments

The authors would like to thank Motorsport UK for providing access to participants.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Stephanie A. Adams http://orcid.org/0000-0002-6838-9812
Peter J. Hutchinson http://orcid.org/0000-0002-2796-1835
Anthony P. Turner http://orcid.org/0000-0003-1202-6649

References

1. McCrory P, Meeuwisse W, Dvorak J, Aubry M, Bailes J, Broglio S, Cantu RC, Cassidy D, Echemendia RJ, Castellani RJ, et al. Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. Br J Sports Med. 2017;51(11):838–47. doi:10.1136/bjsports-2017-097699.
2. Howell D, Osternig L, Van Donkelaar P, Mayr U, Chou LS. Effects of concussion on attention and executive function in adolescents. Med Sci Sports Exerc. 2013;45(6):1030–37. doi:10.1249/MSS.0b013e3182814595.
3. Maas AI, Menon DK, Adelson PD, Andelic N, Bell MJ, Belli A, Bragge P, Brazinova A, Büki A, Chesnut RM, et al. Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. Lancet Neurol 2017;16:987–1048.
4. Bramley H, Patrick K, Lehman E, Silvis M. High school soccer players with concussion education are more likely to notify their coach of a suspected concussion. Clin Pediatr. 2012;51(4):332–36. doi:10.1177/0009922811425233.
5. Kroshus E, Baugh CM. Concussion education in US collegiate sport: what is happening and what do athletes want? Health Educ Behav. 2016;43(2):182–90. doi:10.1177/1090198115599380.
6. Caron JG, Bloom GA, Falcao WR, Sweet SN. An examination of concussion education programmes: a scoping review methodology. Injury Prevention. 2015;21(5):301–08. doi:10.1136/injuryprev-2014-041479.
7. Rhodes MG, Cleary AM, DeLosh EL. A guide to effective studying and learning: practical strategies from the science of learning. Oxford, United Kingdom: Oxford University Press; 2020.
8. Caron JG, Rathwell S, Delaney JS, Johnston KM, Ptito A, Bloom GA. Development, implementation and assessment of a concussion education programme for high school student-athletes. J Sports Sci. 2017; 36(1):48-55. doi:10.1080/02640414.2017.1280180.
9. Howard-Jones P. Neuroscience and education: a review of educational interventions and approaches informed by neuroscience. Educ Endowment Found. 2014;1–61. https://educationendowmentfoundation.org.uk/public/files/Presentations/Publications/EEF_Lit_Review_NeuroscienceAndEducation.pdf
10. Ebbinghaus H. Memory: a contribution to experimental psychology. Ann Neurosci. 2013;20(4):155. doi:10.5214/ans.0972.7531.200408.
11. Delahunty SE, Delahunt E, Condin B, Toomey D, Blake C. Prevalence of and attitudes about concussion in Irish schools' rugby union players. J School Health. 2015;85(1):17–26. doi:10.1111/josh.12219.
12. Kroshus E, Baugh CM, Daneshvar DH, Viswanath K. Understanding concussion reporting using a model based on the theory of planned behavior. J Adolescent Health. 2014;54(3):269. doi:10.1016/j.jadohealth.2013.11.011.
13. Orbell S, Perugini M, Rakow T. Individual differences in sensitivity to health communications: consideration of future consequences. Health Psychol. 2004;23(4):388–96. doi:10.1037/0278-6133.23.4.388.
14. Gerrard M, Gibbons FX, Reis-Bergan M. The effect of risk communication on risk perceptions: the significance of individual differences. JNCI Monogr. 1999;25:94–100. doi:10.1093/oxfordjournals.jncimonographs.a024217.
15. Cacioppo JT, Petty RE. The need for cognition. J Pers Soc Psychol. 1982;42:116–31. doi:10.1037/0022-3514.42.1.116.
16. Grass J, Krieger F, Paulus P, Greiff S, Strobel A, Strobel A. Thinking in action: need for cognition predicts self-control together with action orientation. PLoS ONE. 2019;14(8):E0220282. doi:10.1371/journal.pone.0220282.
17. Jebb AT, Saef R, Parrigon S, Woo SE. The need for cognition: key concepts, assessment, and role in educational outcomes. In: Psychosocial skills and school systems in the 21st century,

Lipnevich AA, Preckel F, & Roberts RD (Eds.). Cham: Springer. 2016. p. 115–32.

18. Cacioppo JT, Petty RE, Feinstein JA, Jarvis BG. Dispositional differences in cognitive motivation: the life and times of individuals varying in need for cognition. Psychol Bull. 1996;119:197–253. doi:10.1037/0033-2909.119.2.197.
19. Cialdini RB, Petty RE, Cacioppo JT. Attitude and attitude change. Annu Rev Psychol. 1981;32(1):357–404. doi:10.1146/annurev.ps.32.020181.002041.
20. McMath BF, Prentice-Dunn S. Protection motivation theory and skin cancer risk: the role of individual differences in responses to persuasive appeals. J Appl Soc Psychol. 2005;35(3):621–43. doi:10.1111/j.1559-1816.2005.tb02138.x.
21. Luttrell A, Petty RE, Xu M. Replicating and fixing failed replications: the case of need for cognition and argument quality. J Exp Soc Psychol. 2017;69:178–83. doi:10.1016/j.jesp.2016.09.006.
22. Horcajo J, Santos D, Guyer JJ, Moreno L. Changing attitudes and intentions related to doping: an analysis of individual differences in need for cognition. J Sports Sci. 2019;37(24):2835–43. doi:10.1080/02640414.2019.1665876.
23. Turner JS, Tollison AC, Hopkins B, Poloskey L, Fontaine D. Sport-related concussion education and the elaboration likelihood model: need for cognition as mediator between health literacy and concussion education efficacy. Commun Sport. 2019; 9(4): 527-549.
24. Adams SA, Turner AP, Richards H, Hutchinson PJ. Concussion in motorsport? Experience, knowledge, attitudes, and priorities of medical personnel and drivers. Clin J Sport Med. 2018 Aug 13. doi:10.1097/JSM.0000000000000647.
25. Deakin ND, Suckling J, Hutchinson PJ. Research evaluating sports concussion events—rapid assessment of concussion and evidence for return (RESCUE-RACER): a two-year longitudinal observational study of concussion in motorsport. BMJ Open Sport Exercise Med. 2021;7:e000879. doi:10.1136/bmjsem-2020-000879.
26. Deakin ND, Hutchinson PJ. Concussion in motorsport: incidence, awareness and future directions. J Concussion. 2017;2(3):43–46. doi:10.2217/cnc-2017-0004.
27. Potkanowicz ES, Mendel RW. The case for driver science in motorsport: a review and recommendations. Sports Med. 2013;43(7):565–74. doi:10.1007/s40279-013-0040-2.
28. Finch CF, Clapperton AJ, Mccrory P. Increasing incidence of hospitalisation for sport-related concussion in Victoria, Australia. Med J Aust. 2013;198:427–30. doi:10.5694/mja12.11217.
29. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. 2013. Developing and evaluating complex interventions: the new medical research council guidance. Int J Nurs Stud. 50(5):587–92. doi:10.1016/j.ijnurstu.2012.09.010.
30. Karlsson P, Bergmark A. Compared with what? An analysis of control-group types in Cochrane and Campbell reviews of psychosocial treatment efficacy with substance use disorders. Addiction. 2015;110(3):420–28. doi:10.1111/add.12799.
31. Rosenbaum AM, Arnett PA. The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. J Clin Exp Neuropsychol. 2010;32(1):44–55. doi:10.1080/13803390902806535.
32. Patton MQ. Qualitative research and evaluation methods. Thousand Oakes, CA: Sage Publications, Inc; 2002.
33. Cacioppo JT, Petty RE, Feng KC. The efficient assessment of need for cognition. J Pers Assess. 1984;48(3):306–07. doi:10.1207/s15327752jpa4803_13.
34. Conner M, Rhodes RE, Morris B, Mceachan RC, Lawton R. Changing exercise through targeting affective or cognitive attitudes. Psychol Health. 2011;26(2):133–49. doi:10.1080/08870446.2011.531570.
35. Brown A, Maydeu-Olivares A. Item response modeling of forced-choice questionnaires. Educ Psychol Meas. 2011;71(3):460–502.
36. Schneider KD, Grandhi RK, Bansal P, Kuntz GE, Webster KE, Logan K, Barber Foss KD, Myer GD. Current state of concussion prevention strategies: a systematic review and meta-analysis of prospective, controlled studies. Br J Sports Med. 2016;51(20):1473–82. doi:10.1136/bjsports-2015-095645.
37. SportScotland. If in doubt sit them out. 2015 [accessed 2016 Dec 4]. http://files.rcp.sg/filestore/1601210337_56a0f295e4f44/Scottish-Sports-Concussion-Guidance.pdf .
38. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, Burroughs H, Jinks C. Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant. 2018;52(4):1893–907. doi:10.1007/s11135-017-0574-8.
39. Field A. Discovering statistics using IBM SPSS statistics. 5th ed. Thousand Oaks, California: SAGE Publications Ltd; 2018.
40. Norman G. Likert scales, levels of measurement and the “laws” of statistics. Adv Health Sci Educ. 2010;15(5):625–32. doi:10.1007/s10459-010-9222-y.
41. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101. doi:10.1191/1478088706qp063oa.
42. Mays N, Pope C. Assessing quality in qualitative research. BMJ. 2000;320(50):50–52. doi:10.1136/bmj.320.7226.50.
43. Hutchinson PJ, Olvey S. Concussion in motor sport. Int J Motor Sport Med. 2015;(5):36–46.
44. Kurowski BG, Pomerantz WJ, Schaiper C, Ho M, Gittelman MA. Impact of preseason concussion education on knowledge, attitudes, and behaviors of high school athletes. J Trauma Acute Care Surg. 2015;79(3):21–28. doi:10.1097/TA.0000000000000675.
45. Manasse-Cohick NJ, Shapley KL. Concussion education for high school football players: a pilot study. Commun Disord Q. 2014; 35(3): 182-185. doi:10.1177/1525740113506605
46. Williams JM, Langdon JL, McMillan JL, Buckley TA. English professional football players concussion knowledge and attitude. J Sport Health Sci. 2016;5(2):197–204. doi:10.1016/j.jshs.2015.01.009.
47. Bakker AB. Persuasive communication about AIDS prevention: need for cognition determines the impact of message format. AIDS Educ Prev. 1999;11(2):150.
48. Latimer AE, Katulak NA, Mowad L, Salovey P. Motivating cancer prevention and early detection behaviors using psychologically tailored messages. J Health Commun. 2005;10:(S1):137–155. doi:10.1080/10810730500263364.
49. Williams-Piehota P, Schneider TR, Pizarro J, Mowad L, Salovey P. Matching health messages to information-processing styles: need for cognition and mammography utilization. Health Commun. 2003;15(4):375–92. doi:10.1207/S15327027HC1504_01.
50. Haug S, Meyer C, Ulbricht S, Gross B, Rumpf HJ, John U. Need for cognition as a predictor and a moderator of outcome in a tailored letters smoking cessation intervention. Health Psychol. 2010;29(4):367. doi:10.1037/a0019450.
51. Cortese J, Lustria MA. Can tailoring increase elaboration of health messages delivered via an adaptive educational site on adolescent sexual health and decision-making? J Assoc Inf Sci Technol. 2012;63(8):1567–80.
52. Kramer AW, Van Duijvenvoorde AC, Krabbendam L, Huizenga HM. Individual differences in adolescents’ willingness to invest cognitive effort: relation to need for cognition, motivation and cognitive capacity. Cogn Dev. 2021;57:100978. doi:10.1016/j.cogdev.2020.100978.
53. An D, Carr M. Learning styles theory fails to explain learning and achievement: recommendations for alternative approaches. Pers Individ Dif. 2017;116:410–16. doi:10.1016/j.paid.2017.04.050.
54. Husmann PR, O’Loughlin VD. Another nail in the coffin for learning styles? Disparities among undergraduate anatomy students’ study strategies, class performance, and reported VARK learning styles. Anat Sci Educ. 2019;12:6–19. doi:10.1002/ase.1777.
55. Nancekivell SE, Shah P, Gelman SA. Maybe they’re born with it, or maybe it’s experience: toward a deeper understanding of the

learning style myth. J Educ Psychol. 2020;112(2):221–35. doi:10.1037/edu0000366.
56. Pashler H, McDaniel M, Rohrer D, Bjork R. Learning styles: concepts and evidence. Psychol Sci Public Interest. 2008;9(3):105–19. doi:10.1111/j.1539-6053.2009.01038.x.
57. Goodman D, Bradley NL, Paras B, Williamson IJ, Bizzochi J. Video gaming promotes concussion knowledge acquisition in youth hockey players. J Adolesc. 2006;29(3):351–60. doi:10.1016/j.adolescence.2005.07.004.
58. Echlin PS, Johnson AM, Riverin S, Tator CH, Cantu RC, Cusimano MD, Taunton JE, Upshur REG, Hall CR, Forwell LA, et al. A prospective study of concussion education in 2 junior ice hockey teams: implications for sports concussion education. Neurosurg Focus. 2010;29(5):E6. doi:10.3171/2010.9.FOCUS10187.
59. Petty RE, Cacioppo JT. Message elaboration versus peripheral cues. In: Communication and persuasion. Springer, New York, NY: Springer. 1986. p. 141–72.
60. Cacioppo JT, Cacioppo S, Petty RE. The neuroscience of persuasion: a review with an emphasis on issues and opportunities. Soc Neurosci. 2018;13(2):129–72. doi:10.1080/17470919.2016.1273851.
61. Chapman EB, Nasypany A, May J, Henry T, Hummel C, Jun H-P. Investigation of the rosenbaum concussion knowledge and attitudes survey in collegiate athletes. Clin J Sport Med. 2018;28(2):117–24. doi:10.1097/JSM.0000000000000421.
62. Teige-Mocigemba S, Klauer KC, Sherman JW A practical guide to implicit association task and related tasks. [accessed 2020 Mar 18]. https://escholarship.org/content/qt63t6n75d/qt63t6n75d.pdf .
63. Fremont P, Schneider K, Laroche A, Emery C, Yeates K. Could a massive open online course be part of the solution to sport-related concussion? Participation and impact among 8368 registrants. BMJ Open Sport Exercise Med. 2020;6:e000700. doi:10.1136/bmjsem-2019-000700.
64. Carvalho P, Sana F, Yan V. Self-regulated spacing in a massive open online course is related to better learning. NPJ Sci Learn. 2020;5(1):2. doi:10.1038/s41539-020-0061-1.
65. SportScotland. If in doubt sit them out. [accessed 2018 April 5]. https://sportscotland.org.uk/media/3382/concussionreport2018.pdf.